TIN-IODATE RECHARGEABLE BATTERY

FIELD OF THE INVENTION

The present invention relates to electrochemical energy storage devices and in particular to the batteries which contain tin and iodate redox reactions in aqueous electrolyte.

BACKGROUND OF THE INVENTION

There is ever increasing demand of advanced battery technologies with high safety and low cost for applications in electrified vehicles and large-scale renewable energy storage. The current commercialized rechargeable batteries, such as Lead-acid battery, display low energy density and environmental unfriendliness with toxic electrode materials. Therefore, Li-ion batteries arrest much attention in recent years. However, although lithium-ion batteries have gained great improvement in energy/power density and life span, the safety issues associated with flammable organic electrolytes and the growing concerns of the high cost and availability of Li resources impede their large-scale deployment. Numerous Li-ion battery accidents causing fires and explosions have been reported. Li-ion batteries are too expensive for large-scale stationary energy storage of the sustainable energy sources, such as solar energy, wind energy, etc.

Unlike traditional batteries, flow-based electrochemical energy storage system separate the energy storage and power generation by storing the electro-active species in externally flowing electrolytes, while maintaining the redox reactions at the electrode surface inside a stack. This unique architecture permits the flow batteries to independently scale the power and energy, enable high safety for intermittent renewable energy integration and other grid services. However, despite continuous progress, the energy density of traditional flow batteries is considerably lower than that of low-end Li-ion batteries. The most promising all-vanadium redox battery is limited to <25 Wh/l by the low solubility of the active species. Improvement in energy density is a necessity to enable the flow battery for applications such as stationary energy storage and electric vehicles.

The purpose of this patent is to invent a new tin-iodate rechargeable battery to meet the demand for the high performance characteristics that include high power, high energy, high reliability and safety, longer life, as well as low cost and environmentally benign.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a rechargeable electrochemical battery with high power density, high energy density, high reliability and safety, longer life, as well as low cost and environmentally benign.

This object is achieved in accordance with the present invention by providing an electrochemical tin-iodate battery with a tin anode, a carbon cathode, a selective permeable separator for separating anodic electrolyte and cathodic electrolyte, acidic aqueous electrolytes.

The said tin anode comprises tin (such as metal tin, tin alloy, a compressed mixture of tin or tin alloy particles with electrically conductive particles and a binder, with or without anticorrosion agents) or carbon (such as graphite felt, carbon felt, carbon cloth, carbon paper, carbon fibre, graphite paper, graphite cloth).

The said carbon cathode comprises carbon (carbon fibre, carbon felt, carbon foam, graphite felt, carbon cloth, carbon paper, graphite paper or a compressed mixture of carbon particles with electrically conductive particles and a binder, etc.).

The said selective permeable separator can be a combination of proton exchange membrane, ion exchange membrane, reverse osmosis (RO) membrane, nanofiltration (NF) membrane, semi permeable membrane, or glass paper, which separates the electrolytes and only allows H^+ to permeate but blocks other ions to cross over.

The said selective permeable separator can be one layer of membrane or a device with multiple membranes.

The said acidic aqueous electrolyte includes anodic stannous electrolyte and cathodic iodic electrolyte.

The said anodic stannous electrolyte comprises at least one of acids, such as sulfuric acid, muriatic acid, nitric acid, sulfamic acid, phosphoric acid, hydrobromic acid, hydriodic acid, acetic acid, citric acid, with or without stannous salt.

The said cathodic iodic electrolyte comprises at least one of iodate, iodide, iodine, iodic acid.

The said tin-iodate battery can be static battery or redox flow battery. Flow battery is preferred for large-scale energy storage and electrified vehicles.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be more readily understood by reference to the following drawing wherein:

FIG. **1** Tin-iodate rechargeable flow battery

FIG. **2** Tin-iodate rechargeable flow battery with two separates and intermediate electrolyte

The referenced drawing is only for the purpose of illustrated embodiments, and is not to be construed as limiting the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention discloses a rechargeable tin-iodate battery which comprises a tin anode, a carbon cathode, a selective separator, and acidic electrolytes.

As shown in FIG. **1**, in a preferred embodiment, the anode **1** is tin and the cathode **2** is carbon fiber. The anodic stannous electrolyte is sulfuric acid and the cathodic iodic electrolyte is potassium iodate solution. The separator **3** is proton exchange membrane Nafion N115. A tin-iodate battery is thus constructed based on the following redox reactions:

Anode:	$3Sn - 6e^- \leftrightarrow 3Sn^{2+}$	$E^0 = -0.13$ V
	$3Sn^{2+} - 6e^- \leftrightarrow 3Sn^{4+}$	$E^0 = 0.15$ V
Cathode:	$2IO_3^- + 12H^+ + 10e^- \leftrightarrow I_2 + 6H_2O$	$E^0 = 1.20$ V
	$I_2 + 2e^- \leftrightarrow 2I^-$	$E^0 = 0.54$ V
Overall:	$3Sn + 12H^+ + 2IO_3^- \leftrightarrow 3Sn^{4+} + 2I^- + 6H_2O$	E = 1.33/0.39 V

The protons in the anodic electrolyte penetrate the selective permeable separator **3** to enter the cathodic electrolyte and participate in the electrochemical reaction during discharging process. Anion such as IO_3^- and I^- including iodine cannot cross over the proton exchange membrane. During the charging process, the protons return anodic electrolyte while iodide ions and iodine are oxidized to iodate with the help of catalysts. The stable open-circuit voltage is 1.55 V, high than the standard electrode potential 1.33 V.

The electrolytes can also start from stannous solution and iodide/iodine solution, without departing from the scope of the present invention. The selective separator can be one